UNCLASSIFIED

AD NUMBER
AD858830
NEW LIMITATION CHANGE
TO Approved for public release, distribution unlimited
FROM Distribution authorized to U.S. Gov't. agencies only; Administrative/Operational Use; AUG 1969. Other requests shall be referred to Naval Civil Engineering Lab., Port Hueneme, CA 93041.
AUTHORITY
Naval Construction Battalion Center ltr dtd 24 Oct 1974

THIS PAGE IS UNCLASSIFIED

Technical Note N-1044

PROTECTION OF FLOATING PONTOONS FROM CORROSION -- PART III. CONDITION OF TEST FLOATS AFTER THREE YEARS

By

Richard W. Drisko

August 1969

Each transmittal of this document outside the agencies of the U. S. Government must have prior approval of the Naval Civil Engineering Laboratory

NAVAL CIVIL ENGINEERING LABORATORY
Port Hueneme, California 93041

20

PROTECTION OF FLOATING PONTOONS FROM CORROSION -- PART III. CONDITION OF TEST FLOATS AFTER THREE YEARS

Technical Note N-1044

YF 38.534.001.01.001

by

Richard W. Drisko

ABSTRACT

A test program had been initiated to reduce the maintenance costs associated with steel pontoon camel floats. Three two-coat protective coating systems had been applied to pontoons on each of three test floats. One test float was cathodically protected with zinc anodes, another with aluminum anodes, and the third without cathodic protection was designed to serve as a control. Two of the three test floats were lost during the past year, and so the third is now kept in a secure area. All three protective coating systems are performing well, and the underwater portions of pontoons continue to receive full cathodic protection from zinc anodes.

INTRODUCTION

Steel pontoons are one of the most widely used structural components in the Naval Shore Establishment. While they find many uses ashore, they are more commonly used in water to impart flotation to structures.

The Navy Public Works Center, San Diego, requested assistance from the Naval Facilities Engineering Command and the Naval Civil Engineering Laboratory in a program designed to reduce the cost of maintaining pontoon floats used as camels by ships of the fleet berthing at Navy docking facilities in San Diego Bay. This type of camel is widely used throughout the Naval Shore Establishment as a fender system to prevent abrasion damage to moored vessels. While thus serving the fleet, the protective coatings on these floats are subject to extensive impact and abrasion damage in addition to their usual deterioration in a hostile marine environment.

BACKGROUND

The Navy utilizes about 450 pontoon camel floats of differing size and design in service to the fleet in San Diego Bay. Available camel floats are secured to a centrally-located pier from which they can be readily delivered to ships desiring their use. It has been the standard practice at PWC, San Diego, to protect the steel pontoons from corrosion with a protective coating of MIL-C-18480A, a cold-applied coal tar coating. Because of the rapid deterioration of this coating by abrasion, fouling organisms, and other environmental factors (Figure 1), it has been necessary to recoat the floats annually.

The Navy Public Works Center, San Diego, desired that the maintenance cycle for camel floats be extended to three or more years. In order to further reduce maintenance costs, they desired that the coating be applied in no more than two coats. Accordingly, three two-coat protective coating systems were selected for testing on pontoon camel floats in San Diego Bay.

Much of the damage to camel floats occurs below the water line (Figure 2), causing them to sink. Thus, cathodic protection was also investigated in this study as a means of extending the service time of the floats before required overhaul and further reducing maintenance costs.

TEST DESIGN

Three coating systems utilizing a corrosion-inhibiting primer and a compatible topcoat were selected for use in the test program. The selections were based on performance of the coating on mooring buoys,[1-11] steel sheet piling,[12-16] and other steel specimens[17] located in a marine environment. The three test coating systems are described below and summarized in Table 1. Their proprietary sources are given in the Appendix. The application of these systems and their analysis have previously been reported.[18]

Paint System 1 consists of one coat of epoxy-polyamide primer (Devran 201) and one epoxy-polyamide topcoat (Devran 204). In previous work[1-17] polyamide-cured epoxies have been found to have good abrasion resistance and perform well in a marine environment.

Paint System 2 consists of one coat of an epoxy-polyamide primer (Proline 2001) and a coal-tar epoxy topcoat (Proline 2002). The coal-tar epoxy coating imparts good resistance to moisture penetration. Although some coal-tar epoxies tend to become brittle when exposed to ultraviolet light, System 2 has performed well in San Diego Bay on a limited number of pontoon floats, as well as on the underwater portion of a test mooring buoy.

Paint System 3 consists of one coat of self-cured zinc inorganic silicate (Carbo-Zinc 11) and one coat of high-build polyamide-cured epoxy (Carboline 190 HB). Zinc inorganic silicates without a top-coating have provided good protection to steel in sea water for two or more years, and a compatible topcoat should extend their service lives considerably. A self-cured rather than a post-cured zinc inorganic coating was used to reduce labor costs, although post-cured zinc inorganics tend to give longer lasting protection.[19] Paint systems similar to System 3 have been used extensively to protect the atmospheric portions of off-shore drilling platforms.

Two different types of sacrificial anodes were utilized in the cathodic protection portion of the investigation. Both of these, zinc and aluminum, have previously been investigated by the Navy for other related work. In the test program, three pontoon camel floats were in-service tested. One of these floats was cathodically protected with zinc anodes, a second with aluminum anodes, and the third was not cathodically protected but served as a control.

Each test float consisted of three pontoons spaced a pontoon length apart and secured together with steel angle-iron bracing. They are commonly called 1 x 5's, because they have a width of one and a length of five pontoons. The test design for the three floats is shown in Figure 3. Each of three paint systems investigated was applied to one of the three pontoons in each test float. The pontoons in each float were arranged randomly as shown in Figure 3, so that each coating system would have the same magnitude of exposure to impact and abrasion damage. The design also permitted a study of the effect of each cathodic protection system on each of the three coating systems.

The three test floats were fabricated by PWC, San Diego. A description of the coating systems along with their actual dry film thickness is given in Table 1, and a material and labor cost analysis is given in reference 13. Two small, flat sacrificial anodes were secured to each cathodically protected pontoon, one on each side near the bottom where they will be continually immersed in sea water.

FINDINGS

In providing service to the fleet, the pontoon floats have been used mostly as camels between ships and piers or between ships (Figure 4). In this capacity they received an accumulation of garbage and other debris thrown over the sides of the ships. The floats also frequently served as working platforms for seamen painting the hulls of ships, and consequently have had paint spilled over their tops and down their sides. Floating oil in the harbor has coated the floats with a film of oil along their water lines. A heavy growth of marine fouling has accumulated below water. As a result of the above conditions much of the test coatings were not readily visible, and it was necessary to scrub the surfaces with a stiff bristle brush before examining the coatings.

The conditions of the test pontoon floats after one-half year[18] and after two years[20,21] of service have previously been reported. During this period no blistering, cracking, or peeling of any of the test coatings was noted. There was no rusting below water on the cathodically protected floats, and the slight rusting of floats above water was related to impact and abrasion damage to the coatings. Periodic measurement of electrical potentials confirmed that the underwater portions of the cathodically protected floats were receiving full protection from corrosion. On the float without cathodic protection there was slight corrosion below water as a result of abrasion damage, but there was no undercutting of any of the coatings in these areas.

Because no records are kept of the location of camel floats in San Diego Bay and because of the frequent movement of ships, it has been necessary to spend considerable time searching among ships for the test floats. When a search was made for the test floats in November 1968, none of them could be found. In order to locate them, a dispatch for assistance in finding them was sent to all Naval activities in San Diego Bay. One float (Float No. 01 with zinc anodes) was subsequently recovered and placed in a secured area of the Pacific Reserve Fleet, but the other two have not been found. They were not among the pile of deteriorated floats scheduled for repair or scrapping and so are presumedly in good condition wherever they are. One workman reported seeing several pontoon floats being lifted aboard a ship bound for Vietnam. This may account for the loss of the two test floats. When such unauthorized appropriations are made, the equipment taken is usually in good condition.

All three coating systems on Float No. 01 were in good condition (i.e., no blistering, cracking, or peeling) and virtually unchanged from

previously described inspections. The pontoon-to-water electrical potentials have been measured periodically with a portable meter using a silver/silver chloride reference half-cell. Latest measurements have fallen slightly from about -1.000 to -0.980 volt, still well above the minimum level of protection (-0.850 volt). In past inspections, Float No. 02 with aluminum anodes generally had pontoon-to-water potentials of -1.02 to -1.04 volts. Plenty of metal remains on the zinc anodes for further cathodic protection. These anodes have a loose film of zinc oxidation products on them as a result of their production of electrical current, but there is no marine fouling. Zinc compounds are reported to be toxic to marine life.

The upper wooden fenders of Float No. 01 were still in good condition, but those located below water had suffered severe marine borer attack at their bolt holes and had been torn partially from the float (Figure 5).

DISCUSSION

All three of the two-coat protective coating systems have performed exceedingly well to date in mitigating corrosion. The use of a two-coat protective coating system results in reduced labor costs, but such a system must be applied with extreme care to steel structures in order to avoid pinholes and holidays that expose metal to a hostile environment. A low-voltage holiday detector, however, may be used to detect such deficiencies and permit correction. Yingst,[22] in a study of epoxy coatings on steel support structures, stated that a minimum of three coats is necessary for good performance and suggested mechanically rounding sharp edges and applying two additional coats of primer to them. For submarine ballast tanks, it is recommended that all edges and welds be given a brush coat of primer before three coats of paint are applied to the tank. The good performance to date of all three test coating systems confirms the excellent coating application[18] by PWC personnel and the fact that flat pontoon surfaces are much easier to coat with a continuous paint film than are sharp irregular surfaces. The excellent coating application is further verified by the low current requirements from the sacrificial anodes for cathodic protection and consequently explains the long anode life.

Both types of sacrificial anodes have performed well in cathodically protecting the underwater portions of floats. Their only obvious difference has been that the zinc anodes were free of fouling while the aluminum anodes had heavy tunicate fouling on them.

The use of sacrificial anodes rather than an impressed current cathodic protection system for small floating marine structures has several advantages. These structures are usually moored in a location remote from a source of electrical power ashore or are of a portable nature and are frequently moved. Also, the underwater portions of these structures are usually relatively small and covered with a protective

coating so that complete protection may be achieved by a limited number of sacrificial anodes. Floats and buoys are lifted from the water at relatively short intervals for removal of fouling, relocation, or inspection of chain. At such times necessary replacement of sacrificial anodes can be accomplished conveniently at very little cost.

A cost comparison based on a three-year service life for a system with one of the three test coatings and cathodic protection (a conservative estimate) and a one-year period of service for a system with two coats of cold-applied coal tar MIL-C-18480A (as previously used in San Diego Bay) is presented in Table 2. From this table, it is estimated that $159 can be saved annually on each float. Cathodic protection should be used on all camel floats, even those with superior coating systems, because the coatings are readily subject to impact and abrasion damage from the severe service conditions.

At the conclusion of the test program, the anodes will be removed and weighed so that an estimate of the total effective service life can be made. Should the float with the aluminum anodes not be recovered, some conclusions can still be made about them. They are known to be reliable for at least two years, and data on the actual pounds per amp-year, driving potentials, and density of aluminum and zinc anode alloys have been reported.[23] Thus, zinc anodes are known to be more costly and heavier than aluminum anodes but have greater long term reliability. In either case, the annual cost for cathodic protection of 1 x 5 pontoon camel floats would probably be no more than $5 and constitute a very minor investment for the protection received.

The relatively rapid loss of fenders below water is caused by marine borer attack where untreated wood is exposed at cut ends (Figure 6) and at bolt holes. This can be avoided by making the necessary cuts before treating the wood (e.g. pressure creosoting). Probably a much better system is to use hard rubber fenders rather than wooden ones. Such fenders are available in a variety of sizes and shapes and have performed well on mooring buoys both above and below water.[25] They are resistant to marine biological attack and absorb impact and abrasion better than do wooden fenders.

The greatest cause for removal of pontoon floats for repair or scrapping is the flooding of pontoons through holes caused by corrosion or impact. Filling of pontoons with polyurethane foam would render the floats unsinkable and would greatly extend their service lives. A study of the costs of such foams and the increased service lives of floats filled with them would be necessary for justification of their use.

CONCLUSIONS

1. All three test protective coating systems are well suited for use on pontoon camel floats.

2. Cathodic protection of the underwater portions of pontoon camel floats is quite cheap and very effective.

3. Treated lower fenders on floats and mooring buoys are readily susceptible to marine borer attack unless they are treated after all cuts have been made.

RECOMMENDATIONS

1. Sacrificial anodes should be used on floating steel structures throughout the Naval Shore Establishment where corrosion of the underwater portions constitutes a significant problem.

2. For protection of steel structures to be exposed to a marine environment, a two-coat protective coating can perform well if special care is given during application to avoid pinholes and holidays. For routine painting, however, a three-coat system is recommended.

3. On floating steel structures rubber fenders should be used underwater in place of wooden fenders subject to marine borer attack.

4. A cost effectiveness study should be made into the foam filling of floating structures throughout the Naval Shore Establishment.

Figure 1. Corroded pontoon requiring recoating.

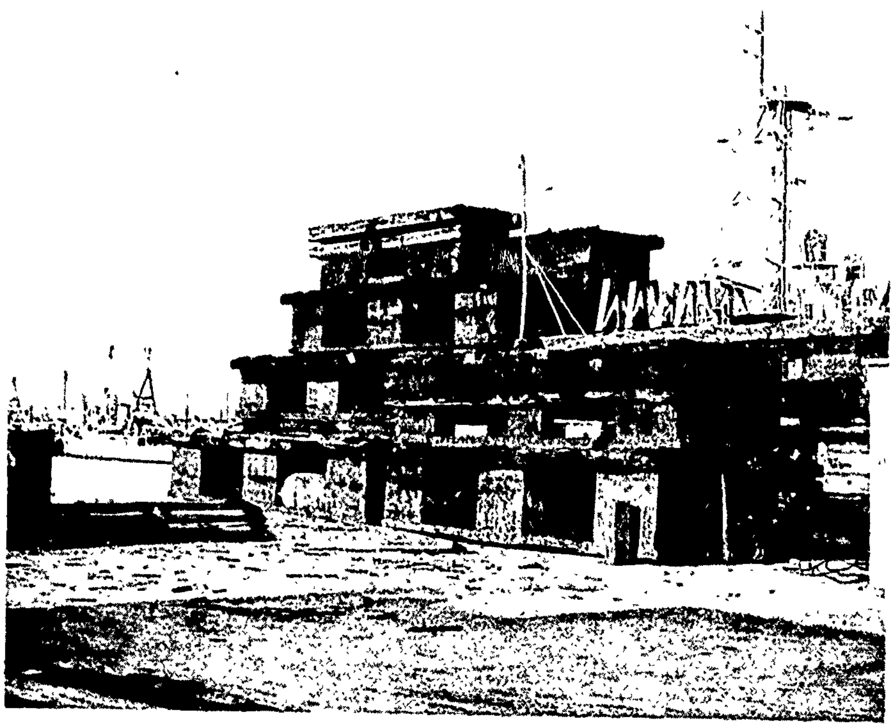

Figure 2. Deteriorated pontoon camel floats removed from service.

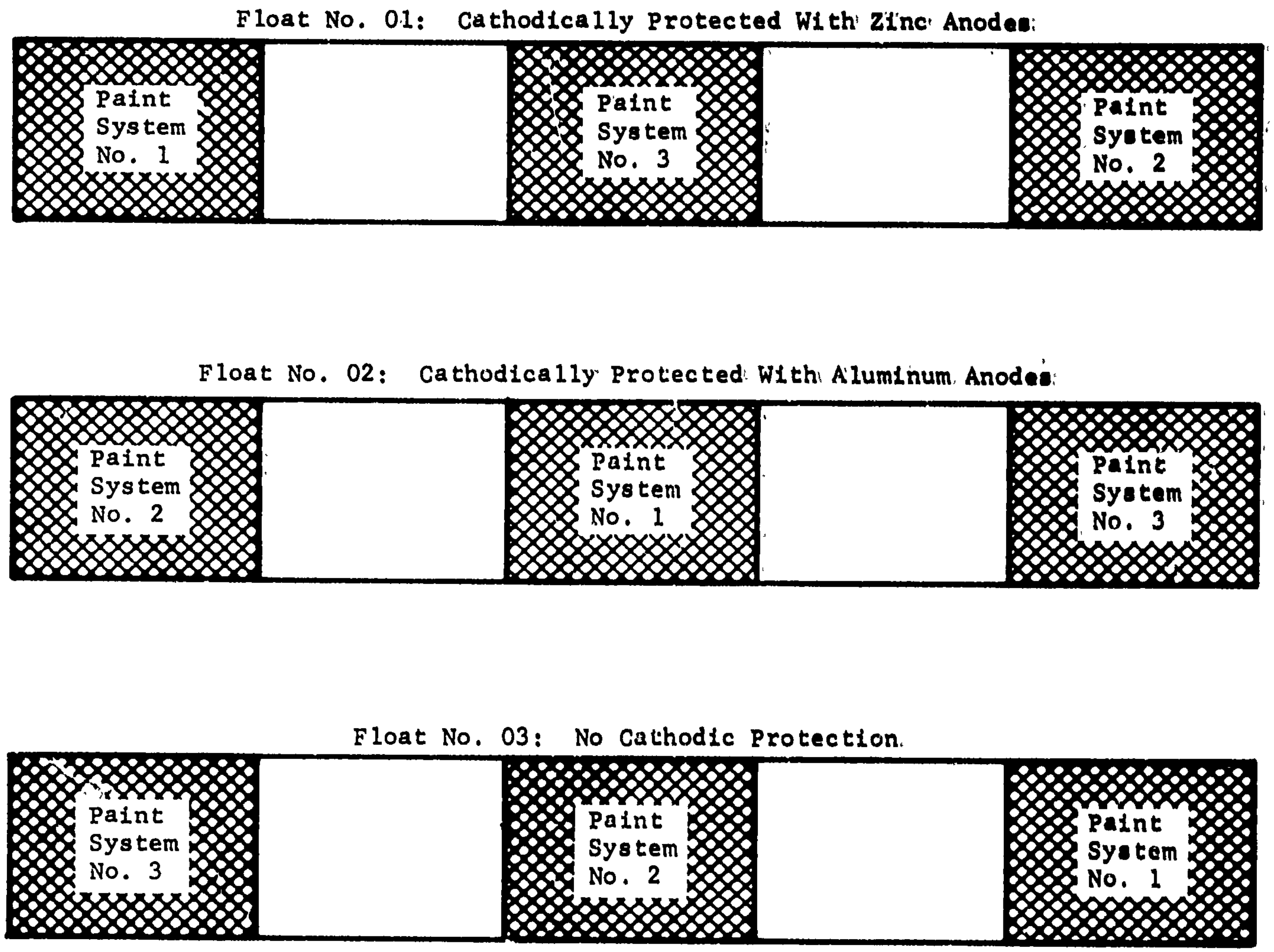

Figure 3. Design of pontoon float test.

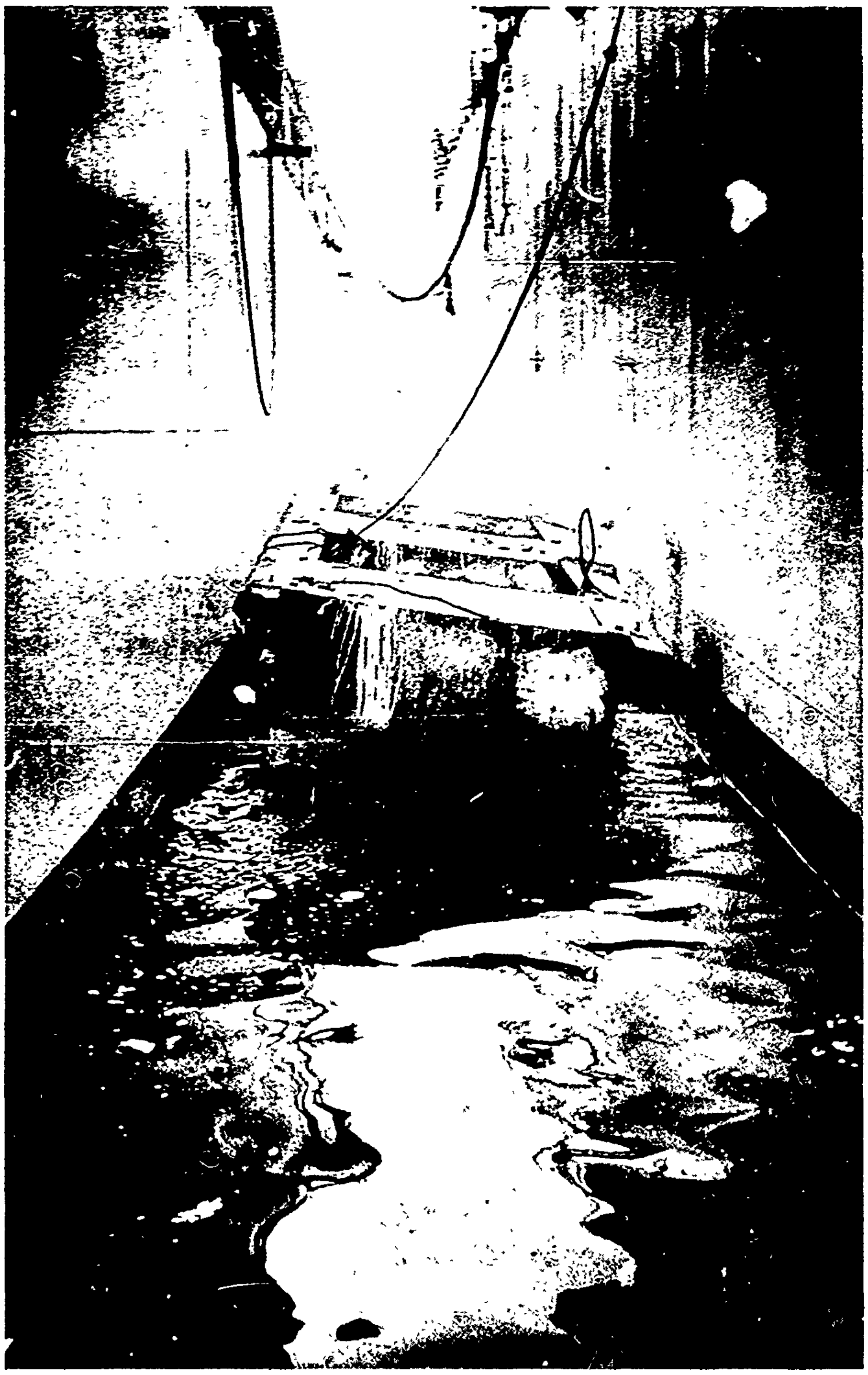

Figure 4. Pontoon camel float between two ships.

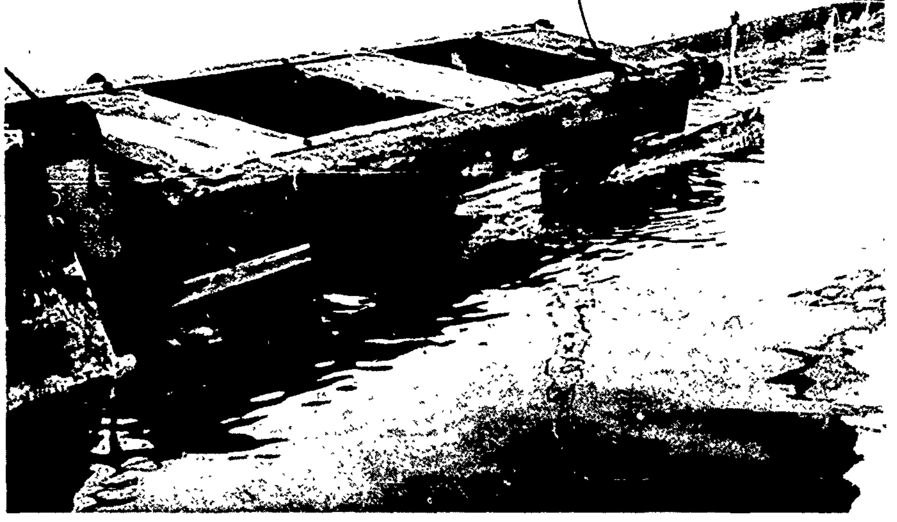

Figure 5. Pontoon No. 01 secured to hull of ship.

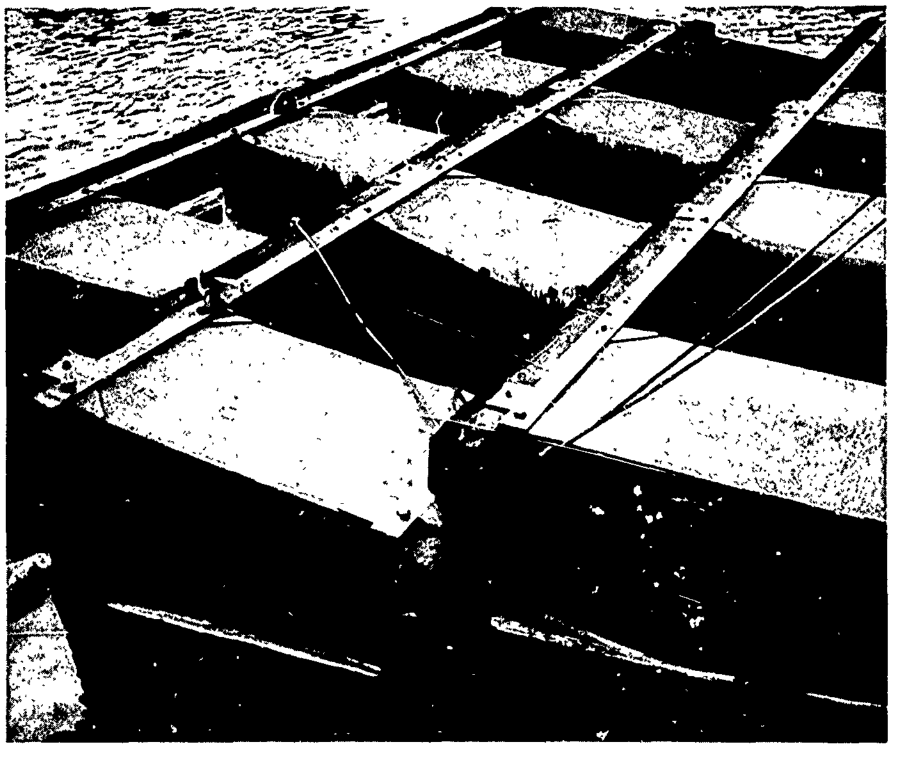

Figure 6. Untreated wood exposed at cut ends of camel fenders.

Table 1. Descriptions of Coating Systems

System Number	Primer			Topcoat			Total Thickness (mils)
	Type	Proprietary Name	Thick-ness (mils)	Type	Proprietary Name	Thick ness (mils)	
1	Epoxy-Polyamide	Devran 201	3	Epoxy-Polyamide	Devran 204	4	7
2	Epoxy-Polyamide	Proline 2001	4	Coal Tar Epoxy	Proline 2002	4	8
3	Zinc Inorganic	Carbo-Zinc 11	3	Epoxy-Polyamide	Carboline 190 HB	6	9

Table 2. Cost Comparison of Two Protection Systems

	Cost in Dollars Per Year	
	Proposed System (Three Year Life)	Coal Tar System (One Year Life)
Coating Material and Application	$ 47	$ 84*
Anode Purchase and Installation	11	0
Float Removal and Replacement	67	200
TOTAL	$125	$284

*Estimated from data in reference 24

Appendix

SUPPLIERS OF PROPRIETARY COATINGS

Devran 201 and Devran 204:	Devoe and Raynolds Company, Inc. 2625 Durahart Street Riverside, California 92507
Proline 2001 and Proline 2002:	Pro-Line Paint Company 2545 Main Street San Diego, California 92113
Carbo-Zinc 11 and Carboline 190 HB:	Carboline Company 32 Hanley Industrial Court St. Louis, Missouri 63144

REFERENCES

1. U. S. Naval Civil Engineering Laboratory. Technical Report R-246: Protection of mooring buoys -- Part I. Initiation of field testing, by R. W. Drisko and R. L. Alumbaugh. Port Hueneme, California, June 1963.

2. ———. Technical Report R-258: Protection of mooring buoys -- Part II. First rating inspection, by R. W. Drisko. Port Hueneme, California, October 1963.

3. ———. Technical Report R-291: Protection of mooring buoys -- Part III. Second rating inspection, by R. W. Drisko. Port Hueneme, California, April 1964.

4. ———. Technical Report R-316: Protection of mooring buoys -- Part IV. Results of third rating inspection, by R. W. Drisko. Port Hueneme, California, June 1964.

5. ———. Technical Report R-355: Protection of mooring buoys -- Part V. Fourth rating inspection, by R. W. Drisko. Port Hueneme, California, January 1965.

6. ———. Technical Report R-385: Protection of mooring buoys -- Part VI. Results of fifth rating inspection, by R. W. Drisko. Port Hueneme, California, December 1965.

7. ———. Technical Report R-431: Protection of mooring buoys -- Part VII. Results of sixth rating inspection, by R. W. Drisko. Port Hueneme, California, December 1965.

8. ———. Technical Report R-458: Protection of mooring buoys -- Part VIII. Results of eighth rating inspection, by R. W. Drisko. Port Hueneme, California, June 1966.

9. ———. Technical Report R-531: Protection of mooring buoys -- Part IX. Results of eighth rating inspection, by R. W. Drisko. Port Hueneme, California, June 1967.

10. ———. Technical Report R-542: Protection of mooring buoys -- Part X. Results of ninth rating inspection, by R. W. Drisko. Port Hueneme, California, September 1967.

11. ———. Technical Report R-585: Protection of mooring buoys -- Part XI. Results of tenth (final) rating inspection, by R. W. Drisko. Port Hueneme, California, June 1968.

12. ———. Technical Note N-260: Corrosion prevention and protective coatings for steel piling, by A. L. Fowler, C. V. Brouillette and H. Hochman. Port Hueneme, California, March 1956.

13. ———. Technical Note N-309: Protective coatings for steel piling: Reports of six-month test, by R. L. Alumbaugh, C. V. Brouillette and A. L. Fowler. Port Hueneme, California, September 1967.

14. ———. Technical Report R-194: Protective coatings for steel piling: Results of 30-month test, by R. L. Alumbaugh. Port Hueneme, California, 1962.

15. ———. Technical Report R-397: Protective coatings for steel piling: Correlation of results of parallel exposures at Port Hueneme and Guam, by C. V. Brouillette and R. L. Alumbaugh. Port Hueneme, California, August 1965.

16. ———. Technical Report R-490: Protective coatings for steel piling: Results of harbor exposure on ten-foot simulated piling, by R. L. Alumbaugh and C. V. Brouillette. Port Hueneme, California, November 1966.

17. ———. Technical Note N-767: Protective coatings in shallow and deep ocean environments, by C. V. Brouillette, R. W. Drisko and R. L. Alumbaugh. Port Hueneme, California, August 1965.

18. ———. Technical Note N-886: Protection of floating pontoons from corrosion -- Part I. Installation and initial performance of test floats, by R. W. Drisko. Port Hueneme, California, April 1965.

19. ———. Technical Report R-561: Zinc inorganic silicates as protective coatings for steel decks of floating drydocks, by C. V. Brouillette. Port Hueneme, California, January 1968.

20. ———. Technical Note N-972: Protection of floating pontoons from corrosion -- Part II. Condition of test floats after two years, by R. W. Drisko. Port Hueneme, California, June 1968.

21. R. W. Drisko, "Cathodic Protection of Buoys, Floats, and Mooring Chain in Sea Water," Preprint of 1968 Conference of National Association of Corrosion Engineers, available from NACE, 2400 West Loop South, Houston, Texas 77027.

22. P. R. Yingst, "Evaluation of Epoxy Resin Coatings on Steel Support Structures," Materials Protection, Vol. 7, No. 1, January 1968, pp. 28-30.

23. G. W. Kurr, "Sacrificial Anode Application in the Seagoing Marine Industry," Preprint of 1969 Conference of National Association of Corrosion Engineers, available from NACE, 2400 West Loop South, Houston, Texas 77027.

24. U. S. Naval Civil Engineering Laboratory. Technical Report R-501S: Cost comparisons of protective coatings for steel, by C. V. Brouillette. Port Hueneme, California, November 1967.

25. ———. Technical Report R-601: Plastic mooring buoys -- Part II. Completion of test program, by R. W. Drisko. Port Hueneme, California, November 1968.

Unclassified
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Naval Civil Engineering Laboratory Port Hueneme, California 93041	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE
Protection of Floating Pontoons From Corrosion -- Part III. Condition of Test Floats After Three Years

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Proprietary July 1968-July 1969

5. AUTHOR(S) (First name, middle initial, last name)
Richard W. Drisko

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
August 1969	18	25

8a. CONTRACT OR GRANT NO. b. PROJECT NO. YF 38.534.006-01.001 c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Note N-1044 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT
Each transmittal of this document outside the agencies of the U.S. Government must have prior approval of the Naval Civil Engineering Laboratory.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Naval Facilities Engineering Command Washington, D.C.

13. ABSTRACT

A test program had been initiated to reduce the maintenance costs associated with steel pontoon camel floats. Three two-coat protective coating systems had been applied to pontoons on each of three test floats. One test float was cathodically protected with zinc anodes, another with aluminum anodes, and the third without cathodic protection was designed to serve as a control. Two of the three test floats were lost during the past year, and so the third is now kept in a secure area. All three protective coating systems are performing well, and the underwater portions of pontoons continue to receive full cathodic protection from zinc anodes.

DD FORM 1 NOV 65 1473 (PAGE 1)
S/N 0101-807-6801

Unclassified
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Protective coatings						
Floats						
Pontoons						
Corrosion						
Steels						
Cathodic protection						
Maintenance						
Cost analysis						